

Current distribution of the exotic freshwater snail *Helisoma duryi* (Gastropoda: Planorbidae) in Brazil

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ABSTRACT

This article describes the current distribution of the introduced gastropod *Helisoma duryi* in Brazil. The species was recorded for the first time in Brazil in 1972, in Formosa, state of Goiás, and since then it has been reported to occur in the states of Ceará, Minas Gerais, Paraíba, Rio de Janeiro, and São Paulo. Recently, this species was found in the state of Ceará, where it was introduced through ornamental fish and aquatic plant trade. The expansion of the species range in Brazil demonstrates the need for increased efforts to monitor and control the introduction of exotic species. Up to now, *H. duryi* had been found in 14 municipalities together with specimens of Ampullariidae, Ancyliidae, Corbiculidae, Lymnaeidae, Planorbidae, Physidae, and Thiariidae. We believe that the current absence of *H. duryi* in the localities where it had been previously collected (1972 and 1998) could be associated with environmental changes in those regions and also because selfing in *H. duryi* is not as efficient as it is for other Planorbidae species. A map with the distribution of *H. duryi* is also provided.

Additional keywords: exotic freshwater mollusks, biological invasions, invasive species, planorbids

INTRODUCTION

Non-native species, those that have been introduced from another geographic region to an area outside its natural range, have been the focus of several investigations in the past years, mostly because they have been closely related to problems in human health, in the environment, and economy. The Convention on Biological Diversity (CBD), ratified in 188 countries, including Brazil, is one of the most important international tools conceived to provide environmental conventions, strategies, and agreements in order to promote sustainable development. In Brazil, where specialists and environmental public bodies recognize the problems involved

with exotic species, CBD signed the Decree number 2.519, seeking to protect and manage biodiversity (Ministério do Meio Ambiente, 2009).

Difficulties in predicting the effects of alien species after introduction were discussed by Meyer et al. (2008), in an investigation on the exotic giant African snail, *Achatina fulica* Bowdich, 1822. According to Ricklefs (2005), every invasion process undergoes four phases: introduction or colonization; settlement, which requires adaptation to local conditions to survive local species interactions; geographical expansion; and eventual decay. The period during which every species remains at each of those phases depends on either intrinsic or extrinsic factors to it. (Incidentally, Brazil is currently experiencing the explosive phase of the invasion of *A. fulica*, and dense populations of that species are widespread in at least 24 out of 26 Brazilian states and the Federal District.)

In Brazil, biological invasions and the pathways of introduction and spread of exotic species are not yet well documented, but a number of instances of the spread of invasive mollusks have been documented in the last decade: Thiengo et al. (2007a) reported the rapid expansion and current distribution of *A. fulica* since its introduction in the state of Paraná, in 1988 while Santos et al. (2002) and Fischer and Colley (2005) reported the occurrence of *A. fulica* in preservation areas in the states of Rio de Janeiro (Ilha Grande, Angra dos Reis) and Paraná (Ilha Rasa, municipality of Guaraqueçaba), respectively, and Takeda et al. (2003) and Mansur et al. (2004) reported the occurrence of the invasive freshwater clams *Limnoperna fortunei* (Dunker, 1857) and *Corbicula* spp. in Southern Brazil. In addition to environmental and economical problems related to exotic snail species, some of those species have medical and veterinary importance as they may be associated with zoonotic and parasitic transmission of diseases (Caldeira et al., 2007; Thiengo et al., 2008).

The aquarium trade is a major source of exotic freshwater mollusks. In 1972, a population of *Helisoma duryi* (Wetherby, 1879), autochthonous from the Everglades wetlands in Florida, was first reported in Distrito de Santa Rosa, municipality of Formosa, state of Goiás, Brazil, in natural breeding sites connected with the Cana Brava River (Paraense, 1975). According to Paraense (1976), these specimens collected in the locality Lagoa da Pedra, in connection with the Cana Brava River, included a large number of albinos obtained from sympatric populations of Ampullariidae, Ancyliidae, Physidae, and other Planorbidae. Similarly, Thiengo et al. (1998) also reported the presence of albino specimens in fish tanks in the municipality of Guapimirim, state of Rio de Janeiro, Brazil, in June 1997 and remarked the importation of aquarium fish trade in the introduction and spread of exotic snails in new sites.

Recognizing the threat to global biodiversity that invasive species play Brazil is one of 188 countries that have ratified the CBD in an effort to help manage this disappearing resource. In 2006 snails were sent from Serra Verde do Saraiva by the Secretaria de Saúde of the state of Ceará (SESA-CE), to the Centro Nacional de Referencia em Malacologia Médica (LRNM) for identification. These snails were identified as *H. duryi*, and prompted surveys of the present distribution of this species in Brazil along with the occurrence of sympatric freshwater snail species were performed and presented.

MATERIALS AND METHODS

Information on the distribution of *Helisoma duryi* in Brazil since its first recorded introduction was obtained from the literature and from data on specimens collected by the authors. Field surveys were performed in three states, from which the occurrence of *H. duryi* was previously reported by the staff of LRNM: Goiás (municipalities of Formosa and Vila Boa), Rio de Janeiro (municipality of Guapimirim), and Ceará (municipalities of Aearape, Fortaleza, Guaiúba, and Redenção).

In the state of Goiás (Table 1), snail collections were performed between 2003 and 2005 in wetland areas along federal highway BR-020, and in Lagoa da Pedra, between the municipalities of Formosa and Vila Boa. In the state of Rio de Janeiro (municipality of Guapimirim) collections were made in 2000, 2003, and 2007 (Table 1) in exotic ornamental fish (*Betta splendens* (Regan, 1910)) breeding tanks. Four municipalities were investigated in the state of Ceará (Table 1): three in the region of Serra Verde do Saraiva (Acarape, Guaiúba and Redenção) and one in the Fortaleza municipality (a lake named Lagoa de Porangabussu).

Mollusks were collected from different habitats (streams, wells, marshy areas, fish tanks and lakes) using collecting sieves. With the aim of assessing abiotic factors in the habitats where *H. duryi* occurs, variables such as temperature (water and air), pH, and the concentration of dissolved oxygen in the water column were

measured using a mercurium thermometer, a pHmeter (Instrutherm pH-1700), and an oxymeter (Lutron DO-5510). Samples were maintained under laboratory conditions at LRNM in aquaria containing dechlorinated tap water and a thin bottom layer of a 2:1 mixture of screened soil and ground oyster shells as a source of mineral nutrients.

For specific identification, the snails were anesthetized with 0.05% sodium pentobarbital (Hypnol[®]) for five hours; killed by immersion in 70°C water and then fixed in Railliet-Henry solution (Fernandez et al. 2008). Snail samples were deposited in the Malacological Collection of Instituto Oswaldo Cruz (CMIOC).

RESULTS

In the state of Goiás (Table 1), eight freshwater gastropod species were found: *Biomphalaria straminea* (Dunker, 1848), *Drepanotrema anatum* (Orbigny, 1835), *Drepanotrema cimex* (Moricand, 1839), *Drepanotrema depressissimum* (Moricand, 1839), *Drepanotrema lucidum* (Pfeiffer, 1839), *Gundlachia radiata* (Guilding, 1828), *Melanoides tuberculatus* (Müller, 1774) and *Pomacea* sp.

In the state of Rio de Janeiro, in the municipality of Guapimirim (Table 1), no *H. duryi* specimens were found but the following species were collected: *Biomphalaria tenagophila* (d'Orbigny, 1835), *B. straminea*, *Hebertancylus moricandi* (d'Orbigny, 1837), *Lymnaea columella* Say, 1817, *M. tuberculatus*, *Physa marmorata* Guilding, 1828, *Pomacea diffusa* (Reeve, 1856), and *Pomacea* sp. (only juvenile specimens).

In the state of Ceará, specimens of *H. duryi* were found in the two habitats, a well and a fish tank (Table 1). In these the water temperatures were 27.3°C and 27.4°C, environment temperatures were 36.8°C and 33.7°C, pH was: 7.76 and 6.38, and dissolved oxygen measured 7.8 mg/L and 7.0 mg/L in the well and the fish pond, respectively. The other freshwater gastropods found in the state were *B. straminea*, *D. lucidum*, *G. radiata*, *H. duryi*, *M. tuberculatus*, *P. marmorata*, *Pomacea lineata* (Spix in Wagner, 1827), *P. diffusa*, and *Pomacea* sp. (only juvenile specimens).

DISCUSSION

According to Paraense (1976) and the data from CMIOC, in August 1972, in addition to *Helisoma duryi*, the following snail species were collected in lakes formed by the Cana Brava River (in the municipality of Formosa, Goiás): *B. straminea*, *Biomphalaria schrammi* (Crosse, 1864), *D. anatum*, *D. lucidum*, *Plesiophysa ornata* (Haas, 1938), *L. columella*, and *P. marmorata*. In the present study, surveys were performed in seven ponds formed by Cana Brava River flooded areas, in the municipalities of Vila Boa and Formosa, but no specimens of *H. duryi* were found.

In the 1990s, many ornamental freshwater fish breeding facilities in the state of Rio de Janeiro were located in

Table 1. Study localities and species found.

State	Date	Municipality	Geographical coordinates	Biotope	Freshwater gastropods (Snail samples and respective the CMIOC collection number)
Goiás	March 2003	Vila Boa	15°03'54.6" S, 47°04'44.8" W	lake	<i>D. lucidum</i> (5199), <i>D. cimex</i> (5201), and <i>D. depressissimum</i> (5200)
		Formosa	15°29'57.5" S, 47°06'37.8" W	lake	No freshwater snail was found.
	May 2005	Vila Boa	15°02'19.9" S, 47°12'04.2" W	lake	No freshwater snail was found.
		Vila Boa	15°02'39.1" S, 47°12'22.5" W	lake	<i>D. anatinum</i> (5191), and <i>M. tuberculatus</i> (5190)
		Vila Boa	15°04'10.8" S, 47°04'20.9" W	lake	<i>B. straminea</i> (5193), <i>D. anatinum</i> (5192), <i>D. lucidum</i> , <i>G. radiata</i> (5194), and <i>Pomacea</i> sp.
	August 2005	Vila Boa	15°04'09.3" S, 47°05'24.1" W	lake	<i>B. straminea</i> (5195), <i>D. anatinum</i> (5196), <i>D. cimex</i> , and <i>D. lucidum</i> (5198)
Vila Boa		15°04'03.8" S, 47°05'40.4" W	lake	<i>B. straminea</i> , <i>D. anatinum</i> , <i>D. cimex</i> , <i>D. lucidum</i> , <i>G. radiata</i> (5197), and <i>M. tuberculatus</i>	
Rio de Janeiro	January 2000	Guapimirim	22°38'21.7" S, 42°58'54.0" W	fish tank	No freshwater snail was found.
	September 2003	Guapimirim	22°38'21.7" S, 42°58'54.0" W	fish tank	<i>B. tenagophila</i> , <i>B. straminea</i> , <i>L. columella</i> , <i>M. tuberculatus</i> and <i>P. marmorata</i>
	January 2007	Guapimirim	22°38'21.7" S, 42°58'54.0" W	tanks	<i>B. tenagophila</i> , <i>H. moricandi</i> , <i>M. tuberculatus</i> , <i>P. marmorata</i> , <i>P. bridgesii</i> and <i>Pomacea</i> sp.
Ceará	October 2006	Acarape	04°11'03.9" S, 38°43'24.9" W	lake	<i>M. tuberculatus</i> (5147) and <i>Pomacea</i> sp. (5202)
		Acarape	04°11'45.3" S, 38°42'55.7" W	lake	<i>B. straminea</i> (5149), <i>D. lucidum</i> (5151), <i>G. radiata</i> (5150), <i>M. tuberculatus</i> (5148) and <i>P. lineata</i> (5203)
	October 2006	Guaiúba	04°10'32.1" S, 38°44'02.2" W	three wells	<i>B. straminea</i> (5153), in one of them
		Redenção	04°10'48.9" S, 38°43'48.0" W	well	No freshwater snail was found.
		Redenção	04°10'55.8" S, 38°43'40.8" W	well	No freshwater snail was found.
		Redenção	04°10'41.2" S, 38°43'51.4" W	well	<i>H. duryi</i> (5152)
		Redenção	04°10'25.3" S, 38°43'52.7" W	well	No freshwater snail was found.
		Redenção	04°10'50.6" S, 38°43'45.3" W	stream	No freshwater snail was found.
		Redenção	04°10'27.2" S, 38°43'49.8" W	lake	<i>G. radiata</i> (5154) and <i>P. lineata</i>
	October 2006	Redenção	04°10'46.8" S, 38°44'02.4" W	fish tank	<i>H. duryi</i> (5157), <i>P. marmorata</i> (5156) and <i>P. diffusa</i> (5204)
		Fortaleza	03°44'45.4" S, 38°32'00.0" W	lake	<i>P. lineata</i> (5146) and <i>B. straminea</i> : only shells
	August 2008	Fortaleza	03°44'37.4" S, 38°32'57.8" W	lake	<i>P. lineata</i> and <i>B. straminea</i>

the municipality of Guapimirim. This probably favored the introduction of exotic species. According to the field work registrations in the LRNM, specimens of *H. duryi* reported by Thiengo et al. (1998) were found in sympatry with *B. straminea*, *Ferrissia* sp., *L. columella* and *P. bridgesii*. The latter is identified as *P. diffusa* nowadays, according to Hayes et al (2008). Many albino specimens of *H. duryi* and *P. diffusa* were also found in those fish tanks in September, 1997. Although no *H. duryi* specimen was found, the present paper confirms the establishment of *P. diffusa*, only species reported by Thiengo et al. (1998) and also obtained in 2007. This

species occurs naturally throughout the Amazon Basin (Peru, Bolivia and Brazil) but it is widespread nowadays due to aquarium and fish trade, specially the more attractive albino specimens known as golden apple snails.

Our results indicate a reduction in *Helisoma duryi* populations in the state of Ceará. In March and May 2006, a team from Secretaria de Saúde of the state of Ceará (SESA-CE) collected samples of *H. duryi* in five localities in the municipalities of Redenção and Guaiúba, and in the present study this species was found in only two of these (Table 1). In the lake Porangabussu, in the

municipality of Fortaleza, where *H. duryi* and *M. tuberculatus* specimens were collected in 1999 by Dr. Fernando Bezerra (Universidade Federal do Ceará) and sent to LRNM for identification, no specimens were found in 2006 and 2008.

The introduction of *Helisoma duryi* was probably the result of aquaculture activity. Ornamental plants are used in fish tanks chiefly to promote water oxygenation. These plants may transport both eggs and early stages of freshwater gastropods, enabling their spread into new environments. Correa et al. (1980) inferred the importance of such plants as vectors for dispersal of non-native mollusks, and noted that they may have been particularly important regarding the spread of schistosomiasis-carrying individuals of *B. straminea* in São Paulo state. They surveyed aquarium and aquatic plant shops throughout the municipality and found specimens of Physidae, Lymnaeidae, Ampullariidae, Thiaridae, and Planorbidae, including *Helisoma* sp. In the same state, França et al. (2007) collected sediment samples in three reservoirs of the Baixo Rio Tietê (Promissão, Nova Avanhandava, and Três Irmãos), in November 2002 and August 2003, in order to identify species of benthic mollusks. Specimens *H. duryi* were found, including another exotic bivalve, *Corbicula fluminea* (Muller, 1774), and the Afro-asiatic gastropod, *M. tuberculatus*. Although *H. duryi* was present in the three reservoirs analyzed, that species had the lowest density among the exotic mollusks.

For an exotic species to be regarded as invasive it must have, at least, considerable adaptability to new environments, rapid sexual maturation, and a large reproductive capacity (Santos et al. 2007). Ecological and parasitological laboratory studies of *Helisoma duryi* obtained in Goiás in 1972 (Milward-de-Andrade, 1978a, b; Milward-de-Andrade and Belisário, 1979; Milward-de-Andrade and Souza, 1979; Milward-de-Andrade et al., 1979) indicate adaptive advantages of that exotic species over *Biomphalaria glabrata* (Say, 1818). These include a higher reproduction rate, lower mortality, higher resistance to environmental desiccation, increased starvation survival, and increased resistance to infection by *Schistosoma mansoni* in that former species.

Other authors reported that *Helisoma duryi* may have the ability to control populations of *Biomphalaria* spp., a vector of schistosomiasis (Frandsen, 1987; Frandsen and Madsen, 1979), in Puerto Rico, St. Lucia, Egypt, and Tanzania. In Brazil, Milward-de-Andrade (1979) argued that the capacity of *H. duryi* to colonize Neotropical ecosystems, either directly or indirectly, may play a key role in the biological control of schistosomiasis mansoni. However, throughout the last three decades, such expected interspecific competition has not been observed (the *H. duryi* population found in 1972, in Goiás, did not successfully establish itself, and was not observed in 2003 and 2005). Remarkably, *M. tuberculatus* was found in this habitat after 2005, having been introduced in Brazil probably by aquarists in Santos in 1967 (Vaz et al., 1986). Currently, *M. tuberculatus* may be found in seventeen Brazilian states and in the Distrito

Federal, in both lentic and lotic habitats, with or without anthropic influences (Fernandez et al., 2003).

Melanoides tuberculatus reproduces parthenogenetically, which may account for its wider geographic distribution when compared to *H. duryi*. The latter may occasionally utilize selfing as an alternative means of reproduction, although it is not as efficient as it is for other Planorbidae species (Paraense and Corrêa, 1988). According to these authors, *H. duryi* benefits much less from functional hermaphroditism which, besides other advantages, enables a single virgin individual to found a new population. Furthermore, other characteristics of *M. tuberculatus*, such as viviparity, iteroparity and high survival rate of the young, may also contribute to its spread (Santos et al., 2007).

In Guapimirim (Rio de Janeiro) and in Lagoa do Porangabussu (Ceará), *B. straminea* appears to have adapted to local conditions, forming colonies, while *H. duryi* has not. Remarkably, in Guapimirim municipality, specimens of *B. straminea* were found in 1997 and 2003, but not in 2007; whereas *B. tenagophila* was recorded in 2003 and 2007. The disappearance of *B. straminea* and the establishment of *B. tenagophila* must be confirmed. In contrast, Silva et al. (1997) reported the replacement of *B. straminea* for *B. tenagophila* in the municipality of Paracambi, Rio de Janeiro.

The introduction of *H. duryi* in the state of Ceará may be a result of *B. splendens* aquaculture (breeding and trade), similar to that described for Guapimirim (Rio de



Figure 1. *Helisoma duryi* from Ceará state, municipality of Redenção (04°10'46.8" S, 38°44'02.4" W).

Janeiro). Ornamental and pet fish such as *B. splendens* originate in Asia and were introduced to Europe and the United States in 1874 and 1910, respectively (Faria et al., 2006). In the 1960s and 1970s, ornamental fish breeders in Brazil introduced production techniques and female individuals imported from Europe and the United States. Since then, individuals of *H. duryi* have been recorded in the following Brazilian states: Minas Gerais, in the municipalities of Viçosa in 1967, and Uberaba (Vidigal et al., 2000); Rio de Janeiro, in the municipality of Nova Iguaçu in 1975; Paraíba, in the municipalities of João Pessoa and Campina Grande (Abilio, 2003); and São Paulo (Corrêa et al., 1980; França et al., 2007). The distribution of the exotic freshwater snail *H. duryi* in Brazil is shown in the Figure 1.

In addition to use of the species in ornamental fish aquaculture, *Betta splendens* was also released under experimental conditions in 2000 as a biological control of the mosquito *Aedes aegypti* Linnaeus, 1758, in the state of Ceará, municipalities of Fortaleza and Canindé (Pamplona et al., 2004). This may in part account for the spread of *H. duryi* in that state. A temporary shortage of rainfall in the state of Ceará in October 2006 made it

difficult to find *H. duryi*, in contrast to March and May, the rainfall season in that region. In October 2006, *H. duryi* specimens (juvenile and eggs) were found in a fish tank of ornamental fish production in Redenção, as well as other snail species such as *P. marmorata* and *P. diffusa*. Recently, Hayes et al. (2008) reported that some ampullariid species, such as *P. diffusa*, may have some characteristics that allow them to become invaders following introduction; its occurrence in Guapimirim (Rio de Janeiro), ten years after its first record, supports Hayes's remark. Furthermore, the presence of *P. diffusa* in Ceará, currently restricted to a fish tank, is reason for concern over the potential for future spread and establishment of new colonies in other areas of Serra Verde do Saraiva. This could happen as a result of the rainy season, a possibility that in itself makes evident the urgent need for monitoring of the local malacofauna.

To date, there is no record of threatened native species, risk of economical loss, or damage to public health that could be triggered by the introduction of *Heliosma duryi* in Brazil. However, this lack of concern may be unwarranted, and preventive measures against the introduction and spread of the species, as well as of others that



Figure 2. Distribution of the exotic freshwater snail *Heliosma duryi* in Brazil: 1, Fortaleza; 2, Guaiúba; 3, Aearape; 4, Redenção; 5, Campina Grande; 6, João Pessoa; 7, Vila Boa; 8, Formosa; 9, Uberaba; 10, Viçosa; 11, Promissão; 12, São Paulo; 13, Nova Iguaçu; 14, Guapimirim.

are associated with environmental damages and public health problems, should be taken. Accordingly, strict law enforcement policies and procedures must be established in the trade of aquatic plants to fish producers as a preventive measure to preserve our biodiversity.

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